Anti-interference technology of communication system

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Abstract: Communication modernization is an important symbol of human societies as we enter into the information age. An important problem encountered in modern communication is interference. With the development of communication, the establishment of various communication networks, making the limited frequency of resources more crowded, intertwined to the serious. How to ensure that the communication is effective, accurate and rapid in the harsh environment conditions in front of today's communications researchers is a difficult problem. As the mobile communication system must use wireless transmission technology in order to achieve the exchange of information in the mobile, wireless transmission is vulnerable to a variety of other radio waves interference, a large number of interference will greatly affect the quality of network communications and system capacity. Anti-jamming technology with strong resistance, strong technical, difficult, practical and reliable high characteristics, in today's increasingly harsh electromagnetic environment, anti-jamming technology is particularly compelling. It can greatly improve the effectiveness and reliability of the communication system in the communication system. Today, anti-jamming technology has become the mainstream of radio communications technology, it is the most closely linked with the field of communications. This paper mainly discusses the interference problem of GSM system in mobile communication anti-jamming technology, including the interference type in GSM, the anti-interference ability of GSM itself and how to optimize the network to achieve the purpose of anti-jamming, so as to meet the requirements of users System capacity while maintaining good call quality.

Key words: GSM anti-jamming network optimization system capacity call quality

Introduction

Mobile communication system appeared half a century ago, it rapid develop after the 80s. The use of digital program-controlled switching technology, the development of INTEGRATED SERVICES DIGITAL NETWORK, the new progress of intelligent network research, and lays a solid foundation for personal communication. Especially with the cellular network technology and the emergence of large-capacity system, mobile communications has become the fastest growing, most popular, most flexible and convenient one of the communication technology.

As with the development of other modern technologies, the development of mobile communication technology has also accelerated the trend. At present, when the digital cellular network has just entered the practical stage, the discussion on the future mobile communication has started with fire, such as vegetable field. Various programs have introduced, one of the most popular is the so-called personal mobile communication network. With regard to the concept and structure of such systems, each interpretation is consistent. But one thing is certain that the future of mobile communication systems will provide global quality services that truly achieve the highest goal of any mobile communication at any time, any location, and to provide communication services to anyone.

The wireless transmission is highly susceptible to interference from various other radio waves. Whether GSM system or CDMA system, they are interference limited system. A large number of interference will greatly affect the network communication quality and system capacity. Mobile communication system mainly has the following interference: the same frequency interference, frequency interference, intermodulation interference, multiple access interference, noise interference. At present, the main anti-jamming technologies are: spread spectrum technology, power control technology, intermittent transmission technology, multi-user detection technology. This paper mainly discusses the direct sequence spread spectrum technology and frequency hopping technology in spread spectrum technology.

1 Introduction

1.1 Communication anti-jamming technology awareness

Communication anti-jamming technology research is known or predicted in the case of interference with the enemy, on the basis of the above technology (of course, do not rule out the new technical categories later) to select appropriate technical means to eliminate or mitigate the interference of the enemy. So that we need to carry out the communication that can continue a technology. The interference with the nature of the enemy, the intensity, the type, the way, the system used, and the clearer the grasp. The more targeted the measures taken, the better the effect. As the enemy's means of confrontation is often integrated, changing, and some may be completely novel, so anti-interference means must take a variety of ways to achieve a better combination of results.

1.2 Communication anti-jamming technology against the method

I. Expanded spectrum anti-jamming technology

1. Frequency hopping technology (FH)

2. Direct Sequence Spread Spectrum (DS)

3. Jump time (TH)

4. Hybrid spread spectrum technology

II. Non-spread spectrum communication anti-jamming technology

Adaptive antenna technology

2. Burst communication technology

3. Error correction coding and interleaving coding

4. Diversity technology

1.3 Communication anti-jamming technology features

(1). Strong resistance, strong technical comprehensive, difficult, fast development, to some extent, interference and anti-interference between the two sides of the wisdom and technology struggle.

(2). The practicality and reliability of the technology requirements, communication interference must be on the battlefield to solve the problem. High and unreliable or impractical is intolerable, and the consequences are unthinkable.

(3). The knowledge points are more complex, and the knowledge system of communication anti-jamming technology covers almost all aspects of communication technology.

2 Frequency Hopping Technology and Its Characteristics

2.1 Frequency hopping technology

Radio communication is an essential means of wartime communication, but traditional radio communications work at a fixed frequency, easily intercepted by an enemy, or exert electronic interference, thus disrupting communications.

Frequency hopping communication is for the shortcomings of traditional radio communications, so that the original fixed radio frequency according to a certain law and speed jump back and forth. From the point of view of anti-jamming communication, frequency hopping communication is to rely on random transitions of carrier frequency to avoid interference. The interference is excluded from the receiving channel to achieve the purpose of anti-interference, to avoid the enemy radio station direction and interference. Frequency hopping communication technology in the anti-jamming communication outstanding advantages, so that it is widely used in communications equipment, and become the main anti-interference technology, ultra-short-wave communications equipment.

Frequency hopping technology is not only a master of external interference, but also for the suppression of long-range radio communication itself caused by multipath interference is also very effective. Since the use of frequency hopping technology, since the main wave beam has been received, and other radial beam has not yet reached the receiver, send and receive carrier frequency has long jumped to other frequency points, thus avoiding the multipath effect on the communication quality Impact.

2.2 Frequency hopping technology in the role of commercial mobile communications

In the service-intensive area, the capacity of the GSM system is limited by the interference caused by frequency reuse, and the relative load-to-dry ratio may vary greatly between calls. Carrier level generally varies with the distance between the mobile station and the base station and the situation of the obstacle between each other. While the interference level is largely dependent on the co-channel interference of neighboring cells. As the goal of the system is to meet the requirements of more users as much as possible, if a frequency of interference, when a user occupies the frequency will cause the call quality degradation, leaving the user difficult to accept, If the interference is continuous, it is easy to cause poor quality out of words. When using frequency hopping, the interference will be shared by other calls of the carrier, the interference is averaged, the interference is no longer in a continuous state and in a sudden state, the performance of the entire network will be greatly improved. By analyzing, the use of frequency hopping network can be higher than the frequency hopping of the network is not high 3dB gain. GSM system using slow frequency hopping technology, frequency hopping rate of 217 hips / sec, frequency hopping in the two time slots, a time slot with a fixed frequency transceiver, the next time slot with another frequency to reduce interference Impact.

3 Direct Sequence Spread Spectrum Technology and Its Characteristics

3.1 Concept and theoretical basis of direct sequence spread spectrum

3.1.1 Direct Sequence Spread Spectrum Concept

The so-called direct sequence (DS: Direct Sequence) spread spectrum, that is directly with a high bit rate of the spread code sequence in the transmitter to expand the signal spectrum. At the receiving end, the same spreading code sequence is used to despread, and the spread spectrum spread signal is restored to the original information.

3.1.2 Theoretical basis of spread spectrum communication

For a long time, people have always tried to make the spectrum of the signal as narrow as possible to fully improve the very valuable frequency of resource utilization. However, the spread spectrum communication is modulated by the spreading code at the transmitting end so that the bandwidth occupied by the signal is much larger than the bandwidth necessary for the transmitted information. The same spreading code is used to obtain the relevant information. Why use wideband signals to transmit narrowband information? Mainly for the safety and reliability of communication. This can be used to explain the basic theory of information theory and anti-jamming theory:

According to Shannon (C.E.Shannon) in the information theory summed up the channel capacity formula, Shannon formula:

$$C = B \log_2 (1 + \frac{S}{N}) \quad (2\text{-}1)$$

Where: C - information transmission rate (channel capacity) unit b / s; S - signal average power unit W; B - band width unit Hz; N - noise average power unit W.

From the formula can be seen:

In order to improve the transmission rate of information C, it can be achieved from two ways, either to increase the bandwidth B or to improve the signal to noise ratio S / N. In other words, when the signal transmission rate C is constant, the signal bandwidth B and the signal to noise ratio S / N are interchangeable, that is, increasing the signal bandwidth can reduce the signal to noise ratio requirements, when the bandwidth increases to a certain extent. The signal-to-noise ratio is further reduced, and the useful signal power is close to the noise power and even submerged under noise is also possible. Spread spectrum communication is the use of broadband transmission technology in exchange for the benefits of signal to noise ratio.

Kejie Ernikov obtains the following formula for the probability of error in information transmission in its potential anti-jamming theory

$$p_e \approx f\left(\frac{E}{n_0}\right) \quad (2\text{-}2)$$

This formula indicates that the error probability Pe is a function of the ratio of the signal energy E to the noise power spectral density. If the information duration is T or the symbol width of the digital information is T, the bandwidth Bm of the information is

$$B_m = \frac{1}{T} \quad (2\text{-}3)$$

The signal power S is

$$S = \frac{1}{T} \quad (2\text{-}4)$$

The width of the modulated (or spread) signal is B, and then the noise power is

$$N = n_0 B \quad (2\text{-}5)$$

(4-3) ~ (4-5) into the formula (4-2), available

$$P_e \approx f\left(\frac{ST}{N} \cdot B\right) = f\left(\frac{S}{N} \cdot \frac{B}{B_m}\right) \quad (2\text{-}6)$$

The above equation indicates that the error probability Pe is a function of the product of the ratio of the input signal to the noise power (S / N) and the ratio of the signal bandwidth to the information bandwidth (B / Bm), and the signal-to-noise ratio and the bandwidth are interchangeable. It also points out the benefits of increasing the bandwidth by means of increasing the bandwidth.

In summary: the information bandwidth expanse 100 times, even with more than 1000 times the bandwidth signal to transmit information, it is to improve the communication anti-jamming capability. That is, under strong interference conditions to ensure reliable and secure communication. This is the basic idea of spread spectrum communication and theoretical basis.

3.1.3 Spread Spectrum Gain and Anti-Interference Tolerance

Spread spectrum communication system due to the expansion of the signal in the transmitter side of the receiver at the end of the solution to restore the information, the benefits of such a system is greatly improved anti-jamming tolerance. Theoretical analysis shows that the anti-jamming performance of various spread spectrum systems is related to the bandwidth ratio of spread spectrum signal after spectrum expansion. The ratio of the spread spectrum signal width W to the information bandwidth, F is generally referred to as a processing gain, i.e.,

$$G_P = \frac{W}{\vartriangle F} \quad (2\text{-}7)$$

It shows the degree of signal to noise ratio improvement in the spread spectrum system. In addition, some other performance of the spread spectrum system is mostly related. Therefore, the processing gain is an important performance index of the spread spectrum system.

The system's anti-jamming tolerance is defined as follows:

$$M_j = G_P - \left[\left(\frac{S}{N}\right)_0 + L_S\right] \quad (2\text{-}8)$$

Where: (S / N). = Signal-to-noise ratio at the output, = system loss

It can be seen that the anti-jamming tolerance is proportional to the gain of the spread spectrum, the gain of the spread spectrum processing is improved, and the interference tolerance is greatly improved, and even the signal can communicate normally under certain noise annihilation. The usual spread spectrum device always extends the bandwidth of the user information (information to be transmitted) to several times, hundreds or even thousands of times to increase the processing gain as much as possible.

3.2 The basic principle of direct sequence spread spectrum

The so-called direct sequence spread spectrum (DS), is directly with a high rate of spread code sequence in the transmitter to expand the signal spectrum. And the receiving end, with the same spread code sequence for dispreading, the spread of the spread spectrum signal to restore the original information. Figure 2-1 shows the schematic block diagram of a DS system.

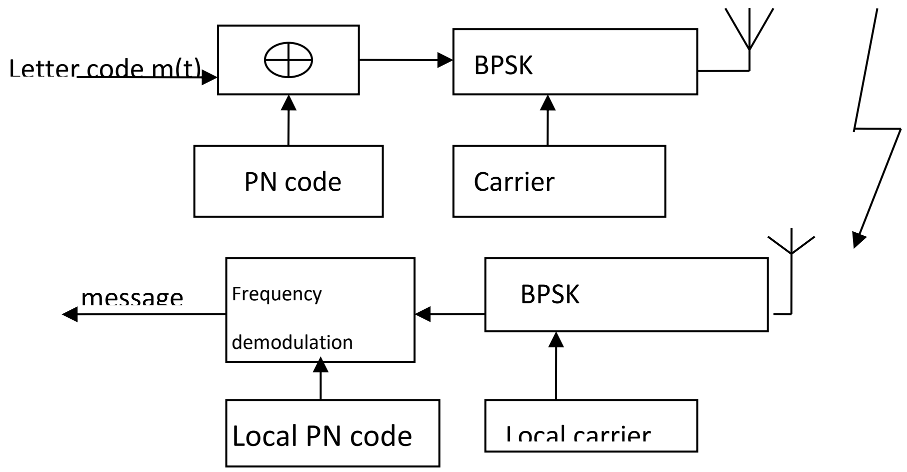

Fig 2-1 Directive communication system

At the sending end, the information symbol m (t) is input, which is binary data, and the symbols are 0, 1, and the symbol width is. Add the spread spectrum demodulator, the figure for the modulo 2 adder, the spread code is a pseudo-random code (PN code), recorded as p (t). The waveform of the pseudo-code is shown in (2) of the waveform in Figure 2-2, and the symbol width is and 16. Usually in the DS system, the rate of pseudo-code is far greater than the signal rate, that is, that is, the width of the pseudo-code is much smaller than the width of the code, that is, in order to broaden the spectrum. The operation rules of the modulo-2 adder can be expressed by the following equation

$$c(t) = m(t) \oplus p(t) \quad (2\text{-}9)$$

C (t) is 0 when m (t) and p (t) are the same and 1 when m (t) and p (t) are different. The waveform of c (t) is the (3) waveform shown in Figure 2-2. It can be seen from the figure that c (t) is the same as p (t) when the code m (t) is 0, and c (t) is p (t) when the code m (t) is 1 Both. Obviously, the c (t) containing the code has its symbol width has become, that is, the spectrum has been carried out. The expansion gain can also be expressed as follows

$$G_p = 10\lg\frac{T_b}{T_p} \quad (2\text{-}10)$$

In some cases, if the pseudo code rate is higher, that is, the narrower the code width (chip width), the greater the spread processing gain.

After the spread spectrum, but also carrier frequency modulation, so that the signal in the channel on the effective transmission. The figure uses two-phase phase shift keying. The phase modulator can be completed by the ring modulator, that is, c (t) multiplied by the carrier frequency, the output is

$$s_1(t) = c(t) A\cos\omega_1 t \quad (2\text{-}11)$$

Therefore, after the spread spectrum and phase modulation of the signal as

$$s_1(t) = Ac(t)\cos\omega_1 t = \begin{cases} A\cos\omega_1 t \\ -A\cos\omega_1 t \end{cases} \quad (2\text{-}13)$$

As can be seen from the above discussion, the spread spectrum modulation signal c (t) can be regarded as a binary waveform of only one, and then the carrier frequency modulation, here is the use of phase modulation (BPSK). The so-called modulation, refers to the multiplication process, can be used multiplier, ring modulator (or balance modulator), and finally get to suppress the carrier double sideband amplitude modulation signal. It is assumed that the balanced modulator is ideally symmetric and the probability of the code sequence is +1, that is, the modulation signal has no DC component, so that the balanced modulator outputs the modulated wave without carrier component. Through the transmitter in the push level, amplifier and output circuit to the antenna to launch out.

Usually carrier frequency is high, or carrier cycle is small, it is far less than the pseudo-code cycle that is satisfied. But in Figure 2-2 (4) shows the carrier waveform = width, which is to facilitate some clearly, or in a period of time to draw dozens or even hundreds of sine wave. For the PSK, the main is to see the tone and the modulation signal between the phase relationships. Figure (2) in Figure 2-2 shows the waveforms that have been modulated. Here, when c (t) is a code, the modulated wave is inverted with the carrier; and when c (t) is 0, the phase is taken. The phase relationship between the modulated wave and the carrier is shown in the (6) the graph in Figure 2-2.

How the receiver works:

Assuming that the transmitted signal is channeled, no error occurs, and the output is still present via the receiver front-end circuit (including the input circuit, high-frequency amplifier, etc.). The channel attenuation problem is not considered here because the PSK modulation signal is important for phase problems, where the assumptions are not affected by the analytical principle of operation. Correlators complete coherent demodulation and dispreading. The frequency of the local oscillator signal in the receiver differs from the carrier by a fixed intermediate frequency. Assume that the terminating PN code (PN) is the same as the originating PN code. The phase of the local phase modulation of the receiver is similar to that of the origin, where the modulation signal is p (t), that is, the phase of the output signal of the phase modulator depends only on p (t), and when p (t) = 1, When p (t) = 0, the phase is zero. The phase of the signal is shown in Figure 2-2 (7).

The effect of the correlator here can be equivalent to the input correlator, the phase modulo 2 plus. For binary system 0, the same number of modulo 2 is added to 0. The different modulus 2 is added. The intermediate frequency phase of the output of the correlator is shown in (8) in Fig. 2-2. Then through the IF filter. Filter out irrelevant interference, the demodulation to restore the original information.

This process illustrates the basic principles of the DS system and how it achieves the benefits of increasing the output signal-to-noise ratio by spreading and dispreading the signal. It embodies the anti-jamming capability of the DS system.

3.3 Synchronous principle of spread spectrum sequence communication system

Any digital communication system is a discrete signal transmission, requiring both ends of the signal in the same frequency and phase on the same, in order to correctly demodulate the information. Spread spectrum communication systems are no exception. A coherent spread spectrum digital communication system, the receiver and the sender must implement the information symbol synchronization, PN code symbol and sequence synchronization and RF carrier frequency synchronization. Only to achieve this synchronization, DSS system can work properly. It can be said that there is no spread spectrum communication system without synchronization.

Synchronization system is the key technology of spread spectrum communication. The information symbol clock can be associated with the PN symbol clock, with a fixed relationship, one for synchronization, and another for natural synchronization. For carrier frequency synchronization, it is primarily for phase synchronization of coherent demodulation. Common carrier frequency extraction and tracking methods can be used, for example, using tracking phase-locked loop to achieve carrier frequency synchronization. So here we only need to discuss PN code symbols and sequence synchronization.

In general, the use of accurate frequency sources in transmitters and receivers eliminates most of the frequency and phase uncertainty. But the factors that cause uncertainty are the following:

1. The distance from the transceiver causes the phase difference in the propagation delay;
2. The frequency difference caused by the relative instability of the transceiver;
3. Doppler shift caused by the relative motion of the transceiver;
4. Multipath propagation will also affect the center frequency changes.

Therefore, it is not enough to improve the stability of the frequency source, and it is necessary to adopt a method of further improving the synchronization rate and accuracy.

The role of the synchronization system is to achieve the local generated PN code and the received signal in the PN code synchronization, that is, the same frequency, the same phase. The synchronization process generally involves two phases:

1. The receiver does not know if the other party has sent a signal at the outset. Therefore, it is necessary to have a search process, that is, search and capture signals within a certain frequency and time range. This stage is also known as the initial synchronization or coarse synchronization, that is, to send the other side of the signal and the local signal in the phase difference into the synchronization within the range, that is, in the PN code when a film.

2. Once this stage is completed, then enter the tracking process, which is to continue to keep pace, not cause of external influence and loss of synchronization. In other words, the synchronization system can be adjusted to keep the transmit and receive signals synchronized, regardless of the frequency and phase of the two ends.

If the cause of the mining caused by out of step, then start a new round of hunting and tracking process. Thus, the entire synchronization process is a process of automatic control and adjustment that includes both phases of the search and tracking closed loop.

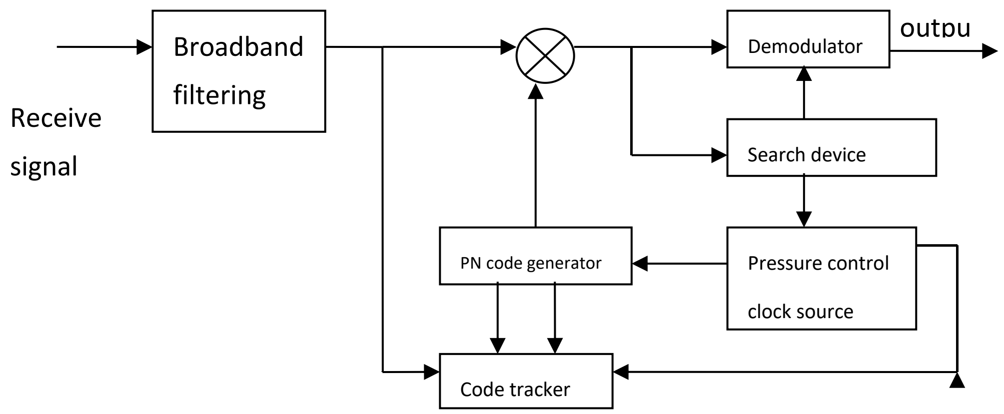

Fig 2-5 Synchronize system searches and tracks

Figure 2-5 for the synchronization system to capture and track the schematic diagram, the signal received by the broadband filter, the multiplier in the multiplier with the local PN code related operations. At this time to search the device, adjust the voltage control clock source, adjust the PN code generator generated by the local pulse sequence pseudo-repetition frequency and phase to search for useful signals. Once the useful signal has been captured, the tracking device is started by adjusting the voltage control clock source to keep the local PN code generator in sync with the external signal

4 Comparison of Frequency Hopping and Direct Sequence Spread Spectrum

Spread spectrum communication technology is widely used in the public network and private network of a wireless communication technology. Spread spectrum communication can be divided into two kinds, direct sequence spread spectrum and frequency hopping. The mechanism of the various spread spectrums is different. It is difficult to assert that some kind of spread spectrum is superior to another kind of spread spectrum, only in certain conditions, the specific analysis of the actual products of different manufacturers, the following two technologies for a simple comparison:

(1) Anti-fading, especially frequency selective fading

Direct expansion system RF bandwidth is very wide. A small fraction of spectral fading does not distort the signal spectrum seriously; for frequency hopping systems, frequency selective fading will cause several frequencies to be affected, resulting in degraded system performance.

(2) Strong resistance to fixed frequency interference

Direct expansion and anti-interference through the relevant dispreading processing gain to achieve the purpose of anti-jamming, but if more than the interference tolerance of fixed frequency interference will lead to interruption of communication system. The general spread spectrum products have multiple channels (Channel), can be 2.4G to 2.4835G range of choice.

Frequency hopping system by carrier random transition, to avoid interference, interference will be excluded from the acceptance channel to achieve the purpose of anti-interference, if the FM system available channel is very large, at a certain frequency of residence time is very short and have a good effect.

(1) Point mentioned above, the slow jump system (the general number of jumps in the 1000 jump below), are frequency hopping products in the low-end products, so a lot of loss of frequency hopping technology.

Slow frequency hopping products are very sensitive to narrowband interference, for example, assuming that the frequency band has a 1MHz bandwidth frequency interference, slow frequency hopping products frequency hopping 100 times per second, then at least once will be mentioned above Of the narrow-band interference, this bit error rate of 10-2, such a high bit error rate for normal communication is not available. Only fast frequency hopping products to avoid narrowband interference, but the cost is very high, the current commercial communication has not fast frequency hopping products.

(3) anti-multipath interference

Multi-path interference is caused by the radio waves in the process of encountering a variety of reflectors (mountains, buildings) caused by the receiver to accept the signal distortion, resulting in inter-code crosstalk, causing noise increases. The DS system can use this interference energy to improve the performance of the system. Frequency hopping system to anti-multipath interference, requiring each jump to stay a very short time, generally to achieve 1M times jump / per second, the actual difficult to achieve.

(4) Synchronization

In addition to the synchronization required by the general communication system, the DS system must complete the synchronization of the pseudo-random code so that the receiver can perform the dispreading of the received signal with the pseudo-random code after synchronization. Direct expansion system with the pseudo-random code word lengthened, the required synchronization accuracy is high, and so the synchronization time is long. Frequency hopping system frequency modulation rate is much lower than the pseudo-random code rate of the DS system, so the synchronization requirements are relatively reduced, the synchronization time is short. Dump system synchronization time is short, fast access network. FM system synchronization time in milliseconds, DSS system time in seconds. But only refers to two spread spectrum equipment boot to communicate time.

(5) Communication security and confidentiality

Direct expansion and frequency hopping systems have strong confidentiality. In addition, for the DSS system, the RF bandwidth is very wide, spectral density is very low, and even sank in the noise, it is difficult to check the existence of the signal. Due to the low spectral density of the DSSS, the impact of the DSS system on other systems is small.

(6) Signal processing

Direct expansion system is generally related to the use of demodulation solution, the modulation using more BPSK, DPSK, QPSK, MPSK modulation. The frequency hopping method due to the frequency of change, the frequency of residence time to complete carrier synchronization, with the frequency hopping frequency increases, the required synchronization time is shorter. So the frequency hopping and more non-coherent demodulation, demodulation methods used mostly FSK or ASK, from the performance point of view, DSS system uses the frequency and phase information, performance is better than frequency hopping. From the implementation point of view, due to coherent detection requires carrier recovery circuit, DC expansion to achieve costly.

5 Status and Development of Communication Interference and Communication Anti - Jamming Technology

Mobile communication can be said occur from the date of the invention of radio communication. In 1897, M.G. Marconi's wireless communication test was conducted between a fixed station and a tug boat at a distance of 18 knots.

The development of modern mobile communication technology began in the 20th century, roughly experienced five stages of development.

For the early stages of development, the first stage started from 1920s to the 1940s. During this period, a special mobile communication system was developed in several bands of shortwave, which represents the car radio system used by the Detroit City police. The system operating frequency of 2MHz, to 40 years to 30 ~ 40MHz can be considered. This stage is the initial stage of modern mobile communications, is characterized by a dedicated system development, the operating frequency is low.

The second stage started from the mid-40s to the early 1960s. During this period, the public mobile communications business began to come out. In 1946, according to the Federal Communications Commission (FCC) plan, Bell system in St. Louis City established the world's first public car telephone network, known as the 'city system.' (1956), France (1956), the United Kingdom (1959) and other countries have developed a public mobile phone system. The use of three channels, the interval is 120 kHz, communication for the simple work, Bell Labs has completed the continuation of manual switching systems. This stage is characterized by a special mobile network from the public mobile network transition, the way for the artificial, the network capacity is small.

The third stage started from the mid-1960s to the mid-1970s. In the meantime, the United States launched an improved mobile phone system (1MTS), the use of 150MHz and 450MHz band, using large area system, small and medium capacity, to achieve the wireless channel automatically selected and can automatically connect to the public telephone network. Germany has also introduced the same technical level of the B network. It can be said that this stage is the stage of mobile communication system improvement and improvement, which is characterized by large area system, small and medium capacity, the use of 450MHz band, to achieve automatic frequency selection and automatic connection.

The fourth stage started from the mid-70s to the mid-80s. This is the period when mobile communications flourish. At the end of 1978, the United States Bell Labs successfully developed advanced mobile phone system (AMPS), built a cellular mobile communication network, greatly improving the system capacity. In 1983, for the first time in Chicago put into commercial use. In December of the same year, it begins in Washington. After that, the service area gradually expanded in the United States. To March 1985 has been extended to 47 areas, about 100,000 mobile users. Other industrialized countries have also developed a cellular public mobile communication network. Japan launched the 800MHz Car Phone System (HAMTS) in 1979, which was put into commercial use in Tokyo, Ghana and Kobe. West Germany in 1984 to complete the C network, the band is 450MHz. The United Kingdom in 1985 developed a full address communication system (TACS), first put into use in London, later covered the country, the band 900MHz. France developed 450 systems. Canada launches 450MHz mobile phone system MTS. Sweden and other Nordic countries in 1980 to develop NMT-450 mobile communication network, and put into use, the band is 450MHz.

The fifth stage begins in the mid-1980s. This is the development and maturity of digital mobile communication systems.

The first generation cellular mobile communication network represented by AMPS and TACS is a simulation system. Although the simulation of the cellular network has achieved great success, but also exposed some problems. For example, low spectrum utilization, complex mobile devices, more expensive, restricted business types and easy eavesdropping, the most important problem is that its capacity has been unable to meet the growing demand for mobile users. The solution to these problems is to develop a new generation of digital cellular mobile communication systems. Digital radio transmission spectrum utilization is high, can greatly improve the system capacity. In addition, the digital network can provide voice, data, a variety of business services, and compatible with ISDN. In fact, as early as the late 1970s, when the analog cellular system was still in development stage, some developed countries were working on digital cellular mobile communication systems. By the mid-1980s, Europe first introduced the Pan-European Digital Mobile Telecommunications Network (GSM) system. Subsequently, the United States and Japan also developed their own digital mobile communication system. Pan-European GSM has been in commercial operation in July 1991 and is expected to cover major European cities, airports and highways in 1995. It can be said that in the next ten years, digital cellular mobile communications will be in a period of great development, and may become the main system of terrestrial public mobile communications.

In recent years, mobile communications in the global rapid development, digital and network has become an irreversible trend. China's mobile communications industry is also reform, improve service quality, and increase market development efforts, to maintain a rapid and healthy development momentum. Since 1987, China's mobile communications industry with an average annual growth rate of 80% -100% rapid development. In 1987 China's cellular mobile phone only 3200 users, in 1999 reached 43.24 million. So far this growth rate is still to continue, which simulation technology has been out of the stage of history. At present, China's 3G network coverage is gradually improving, people are closely watching the development of the dynamic at the same time, China Mobile TD-LTE network construction started, China

Mobile is responsible for the construction of 4G-scale technology test network TD-LTE has made new progress. This marks the TD-LTE industry to enter a new stage, TD-LTE network construction project started. Perhaps China's mobile communication network will gradually toward a higher level of development.

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